# ECSCRM 96, Heraklion, Crete, Greece 6-9 October 1996

The first European Conference on Silicon Carbide and Related Materials (ECSCRM 96) followed about a year after the International Conference in Kyoto, Japan (ICSCRM '95), a tough act to follow indeed with 400 participants. Nevertheless with more than 140 participants and 92 accepted presentations ECSCRIM'96 was at the same levels as ICSCRM '91 and was another indication that SiC and GaN-related fields are among the hottest topics in compound semiconductor research.

It is also encouraging that the importance of this event was recognized by the Commission of the European Union (EU) to the extend that supported the organization of the conference through the "Euroconferences"action (DGXII). In addition, the conference was further sponsored by the Greek government and the US Army/European Research office.

ECSCRM '96 was organized by the Microelectronics Research Group in Crete, Greece, of the Institute of Electronic Structure and Laser of the Foundation for Research & Technology-Hellas (FORTH). It was held at the Fodele Beach Hotel, a resort hotel near Fodele village, the birthplace of the famous renaissance painter El Greco. Fodele village is located about 30 km from the city of Heraklion and the hotel is built on a picturesque bay. The weather was perfect until the very last day, but even then the brief storm cooperated by starting right after the visit to the Knossos archaeological site.

The conference dinner was acknowledged as a great success with the attendees making a smooth transition from spectators to participants in Greek dancing which continued well into the morning hours!

*Delegates at the closing ceremony of ECSCRM'96 at the main ampitheatre of FORTH at Vassilika Vouton, Heraklion, Crete, Greece.*

## Statistics

Several trends can be indicated from a statistical analysis on participants, contributions and industrial participation. Based on number of participants (90 out of 145), the number of presentations (61 out of 92) and on the national origin of the industrial participation (9 out of 12 European Companies represented) it seems that the most active European countries in the field are Germany, France and Sweden. Other Countries from Europe represented at the conference were Russia, Spain, Greece, The United Kingdom, Poland, Finland, Hungary and Italy. Japan was also represented and there was a strong presence from the USA.

Another interesting observation is that presentations devoted to material aspects were slightly more (47) than those on devices (37) indicating that material quality is still an important issue in the SiC-related field. Furthermore, most of the presentations (72) corresponded to single country efforts probably indicating that most research funding still originates from national funds rather than from the EU.

Thanks to the funding of the Commission of the EU, the participation of young researchers was significant and higher than usually encountered in such events.

## Conference presentations

One can only refer to a few papers in an article such as this and apologies are extended to those delegates where presentations are not reported below. All 31 oral presentations were well attended and well received and the two crowded poster sessions did justice to the 61 posters presented with lively discussions. The two panel discussions were even more lively and ran well past their designated time slots.

The conference opened with two plenary talks given by Dr W. J. Choyke (Pittsburgh University) on optical properties and Dr J. Lasseur (Schlumberger Industries) on the prospective


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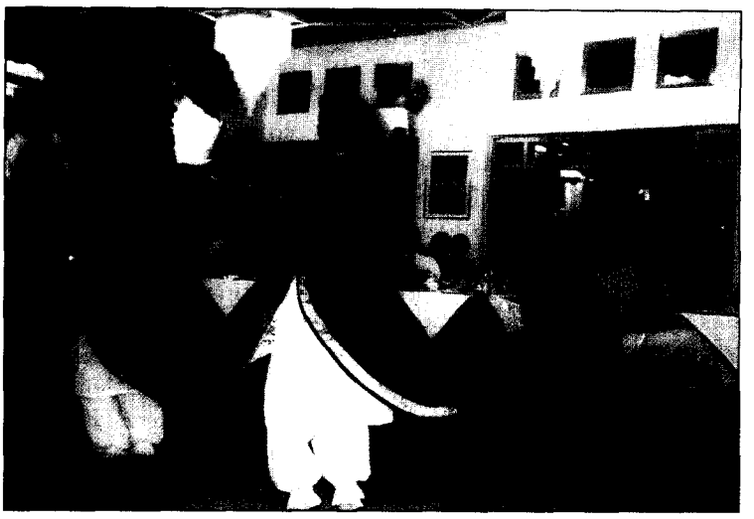
of SiC applications in Europe. These talks were representative of the two main research sectors covered by the majority of presentations, i.e. the SiC material aspect and the device-oriented aspect as well as balancing academic and industrial participation.

The conference proceeded with presentations on bulk growth of SiC, which is an activity well developed in Europe through the ely-modified technique. There are 4 main sites of research, i.e. the Electrotechnical University of St Petersburg in Russia, Erlangen University in Germany, the Polytechnic Institute of Grenoble in France and Linköping University in Sweden. According to the presentations, the main issues in bulk growth are still the reduction of micropipes and the increase of wafer diameter. Most research groups use thermodynamic calculations for growth mechanisms to simulate the growth process and determine the origin of the defects. Such analysis was presented by Dr D. H. Hoffman from Erlangen University. In addition, modifications to the growth chamber and growth protocol, such as the sublimation etching of the damaged surface prior to crystal growth proposed by the group of Dr R. Madar at INPG (Grenoble), improve material quality. The dual seed method is used by the group of Dr G. Pensl for studying the effect of different surface polarity under identical growth conditions.

On the subject of epitaxial growth, the two pioneers of SiC-research, namely Drs H. Matsunami (Kyoto University) and R.F. Davis (North Carolina University) gave presentations on step-flow epitaxial growth and gas-source molecular beam epitaxy of SiC and SiC/AlN heterostructures respectively, addressing critical issues in SiC epitaxy. Dr Henry from Linköping University, "Sweden's focal point of SiC activity", reported new results for 4H-SiC epitaxy by the hot-wall CVD method for various substrate orientations. Cubic material inclusions is the main issue in this case. Dr J.P. Bergmann, also from Linkoping University, presented his work on time resolved photoluminescence spectroscopy on 6H and 4H-SiC. The PL decay time has been measured for the nitrogen and aluminum bound exciton in different polytypes.



*Delegates relaxing and enjoying the conference dinner while observing Cretan folk dancing.*

On the subject of devices Dr J. W. Palmour from Cree Research explained the remaining issues in SiC device technology. Oxide quality and reliability are the major concerns for fabricating SiC-based MOSFETs that can be commercially viable. Reducing micropipe density to $< 1cm^{-2}$ and increasing wafer diameter are both necessary for the fabrication of practical power devices. Dr C. Brylinski from Thomson-CSF and Dr D. Stephani from Siemens presented the activities of their companies on microwave power applications and MOSFET technology respectively. Remote plasma enhanced chemical vapor deposition as an alternative method for oxide fabrication was presented in several oral and poster presentations by the group at RWTH Aachen. The fabricated oxides exhibit defect densities as low as that of the thermally grown ones, albeit with the advantage of much higher growth rates.

On GaN-related issues, Dr S. Krukowski (Unipress, Poland) reported new results on GaN bulk growth by gas transport under high pressure performed at the High Pressure Research Center of Poland. Crystals of 0.5x0.5cm dimensions have been grown. Dr T. Moustakas (Boston University) reported on the epitaxial growth of GaN layers either on sapphire or SiC substrates. In the latter case HBT transistors with a current gain in excess of $10^5$ have been demonstrated. Very interesting results in terms of material properties were obtained by using the zinc-blende (cubic) structure instead of the commonly used wurtzite structure. Finally a plethora of micromachined devices and colour sensors fabricated with hydrogenated amorphous silicon carbide alloys by Daimler Benz has presented by Dr G. Muller.

The two panel discussions entitled "European effort on SiC wafer production and SiC bulk and epitaxial growth apparatus" and "SiC applications and European industry" were coordinated by Dr A. Winnacker and Dr G. Pensl respectively, both from Erlangen University. Apparently, the main technology issues are the quality, diameter, price and number of suppliers of SiC wafers. European industries are well involved in SiC-device related research. However, in order to facilitate the conversion of research into production of SiC devices, the density of micropipes must decrease to $< 1cm^{-2}$, at least 2-inch wafers must be available and more than one supplier of SiC wafers must exist in the market. There was an extended discussion on the last point but it was not clear yet as to the time of initiation of SiC wafer production by Nippon Steel (represented by Dr M. Kanaya) or about product specifications. On the other hand ATMI, according to Dr P. Dobrilla, should be capable to initiate production of high quality (industrial grade) SiC wafers within 6 months after receiving the necessary funding. According to the predictions of some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panellists, 2-inch wafers will be commercially available during 1997, while an increase in size of about 1-inch every two years will be the trend for the next 10 years. Two European companies (AIXTRON and EPIGRESS) are active as CVD reactor suppliers for SiC epitaxy.

From the point of view of applications, microwave and power devices as well as high temperature sensors will be the first products in the market while microwave oven and power switches will become available after the prices of wafers are substantially lowered. In the case of high temperature sensors and power switches the use of the SiC deposited-on-SOI technology seems to be promising.

The major industrial players in Europe, involved in SiC technology, are Outokumpu (SiC substrate supplier), Siemens (communications, aerospace, nuclear reactors) which is involved in substrate, epilayers and device fabrication, Daimler Benz (automotive, aerospace, communications) which is involved in epilayer, device and MEMS fabrication, Thomson (microwave device-based applications) involved in device fabrication, ABB (power device-based applications) through Linköping University which is involved in epilayer and device fabrication and, finally, Schlumberger (sensors) and Schneider Electric (high-voltage-related applications).

The proceedings of ECSCRM '96 will be published in the near future issue of the journal *Diamond and Related Materials*. The next conference will be held in Montpellier, in 1998.

For more information please contact Dr J.L. Robert, Groupe d'Etudes des Semiconducteurs, University of Montpellier II, Pl. Eug. Bataillon, 34095 Montpellier, Cedex 5, France. Fax: +33-4 67143760.

Contact:
Organizing Committee, ECSCRM'96
Institute of Electronic Structure & Laser
Foundation for Research & Technology
Hellas, PO Box 1527, 711 10 Heraklion
Crete, Greece
Tel: +30-81-394105
Fax: +30-81-394106
e-mail: trifili@physics.uch.gr

To keep up-to-date with the latest SiC research readers are reminded that the next international SiC conference will take place in Stockholm, Sweden, 31 August-5 September 1997. The International Conference on SiC and III-Nitrides (ICSCIII-N '97) will follow on from ICSCRM '95 in Kyoto, Japan. Program Chairman is Prof B. Mournar at Linköping University, S-58183, Sweden. Tel/fax: +46-13-281797/142337. E-mail: bom@ifm.liu.se
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